DOCUMENT RESUME

ED 283 122 CS 008 796

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TITLE The Development of Decoding Skills, Reading Comprehension and Spelling Skills in Dutch Primary Schools: A Longitudinal Investigation.
PUB DATE Apr 87
NOTE 18p.; Paper presented at the Annual Meeting of the American Educational Research Association (Washington, DC, April 20-24, 1987).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Cognitive Development; *Decoding (Reading); Elementary Education; Foreign Countries; Grade 1; Grade 2; Grade 3; Grade 6; *Literacy; Longitudinal Studies; *Reading Comprehension; Reading Improvement; Reading Research; Reading Skills; Reading Writing Relationship; *Spelling
IDENTIFIERS *Netherlands

ABSTRACT

This investigation--the first Dutch longitudinal research project on reading and spelling spanning the whole 6-year period of primary education--examined (1) whether it is possible to identify certain aspects of literacy--namely decoding skills, reading comprehension, and spelling skills--within verbal intelligence as latent variables, and whether, if this is the case, these variables remain sufficiently constant during the elementary school; (2) the interrelations among these three skills in terms of growth; and (3) whether causal effects found in a cross sectional approach would be "explained away" in longitudinal research. Subjects, 582 first-graders from 12 randomly selected Dutch schools, were tracked in grades one, two, three, and six, beginning in 1979. Results indicated that in grade three the influence of reading comprehension on spelling was lower than in the first two grades, but that in grade six this influence increased considerably. The direct influence of decoding skills on spelling, however, was smaller than in the first three grades. Results also showed that in grade six correlations and path coefficients between decoding skills on the one hand, and reading comprehension and spelling on the other, remained as a remnant of a causal connection that existed during an earlier developmental stage, but that these relationships were developmentally limited. In most cases the connections between the latent variables of the same name were much stronger than the relations with the other ones, an indication that the differences related to these latent variables were stable, especially for decoding skills. (Twenty-one references, two tables of data, and three figures are included.) (NKA)

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The Development of Decoding Skills, Reading Comprehension and Spelling Skills in Dutch primary schools: A longitudinal investigation

Introduction

One of the most important goals in primary education is the development of academic skills such as reading, writing and arithmetic. If pupils do not attain these goals, this will have a strong negative impact on their further development. It appears that a number of children have difficulties in learning to read and to spell. One of the steps on the way to help these children is more knowledge about the development of the reading and spelling skills. Especially the improvement of reading among those whose progress is deficient, as well as among the highest achievers, is of great importance today. In a sense, we have just seen a third literacy revolution, brought about by the great increase of knowledge and by the efficiency of the media in conveying it. This knowledge revolution has brought with it the need for a higher level of literacy among more people than ever before (Chall, 1983).

The need for efficient and accurate means of predicting academic achievement in reading at an early stage has been emphasized by many researchers. Longitudinal studies, particularly those spanning more than just 1 or 2 years, are especially important in this area of research. Only a small number of longitudinal studies are available, which cover the whole period of primary education. Most investigations are cross-sectional. Although cross-sectional studies are relevant, longitudinal research is necessary to discover causal relations and possible changes occurring within a given period of time. The possibility that causal links are developmentally limited deserves further investigation. Causal effects found in cross-sectional regression analysis are often "explained away", when data relating to the lagged dependent variable are collected and included in the equation as an additional regressor (Oud, 1978). In the design of the present investigation, this has been taken into account.

The writing system is the basic tool of literacy. An analysis of learning to read shows that a universal task in all languages is to learn how the writing system represents language. But this tool varies from one language to another. The Dutch orthographic system is much more regular than the English and the French ones are. It would be interesting to gather similar data with different language systems and to compare the results.

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This investigation is the first Dutch longitudinal research project on reading and spelling development spanning the whole six-year period of primary education. Some reports on this investigation have been published already (Mommers et al., 1986; Boland & Mommers, 1986). In this article new secondary analyses are presented, including new data gathered in grade 6.

Research questions

In the curricula of primary schools a distinction is usually made between different aspects of language teaching viz. decoding skills, reading comprehension and spelling skills. The question arises whether it is possible to identify these three aspects of literacy within the verbal intelligence factor and to consider them as latent variables. And if this is the case at various stages of development, whether the nature of these variables remains sufficiently constant during the primary school period to consider them as the same kind of variables.

The second question deals with the relations between these latent variables. The focus of this study is the development of decoding speed, reading comprehension and spelling, and the interrelations between these skills in terms of growth.

The link between decoding and reading comprehension has been the object of a number of investigations. Early efficient word recognition seems to lead to better comprehension, rather than the other way around (Calfee & Piontkowski, 1981; Lesgold, Resnick & Hammond, 1985). With automatic word recognition, attention can be more fully focused on comprehension (LaBerge & Samuels, 1974). Perfetti and Lesgold (1979) suppose that during a reading activity various subskills are competing for the limited capacity of the working memory. In experienced readers the subprocesses at the level of word recognition largely operate automatically; they no longer tax the limited processing capacity. Although automaticity in word processing skill seems to occur very early -by the second or third grade- for many children, young readers have not yet fully developed automaticity of recognition. The extent to which these subprocesses call upon the working memory capacity constitutes an important source of individual differences between good and poor comprehenders. If this is correct, the disparities in reading comprehension can largely be explained by the differences in word recognition speed or decoding skills. Shanahan's (1984) results support the hypothesis that automatic lower level skills are critical to higher order cognitive

processes. For these reasons an influence from the latent variable Decoding Skills on Reading Comprehension is postulated in this study.

It is assumed that Decoding Skills and Spelling Skills are distinguishable, since the development of pattern recognition mechanism as to visual features of words and spelling patterns is crucial in reading, whereas spelling depends on the permanent storage of information regarding the component letters and their sequence (Seymour & Porpodas, 1980). The fact that Spelling Skillls lag behind reading ability means that pattern recognition of words and parts of words does not imply that the spelling structure of those words has been stored in long term-memory. It is conceivable that Decoding and Spelling Skills exert a mutual influence on each other (Stanovich, 1986). However, in view of the abovementioned argument, we suspect that the influence of Decoding on Spelling will be stronger than vice versa.

Despite the rather high correlations usually found between Reading Comprehension and Spelling, the nature of this relationship is not so clear. In the literature no obvious reasons were found for a direct influence of one variable on the other. If, by way of a hypothesis, an influence were postulated, we would be inclined to assume an influence from Reading Comprehension on Spelling, rather than vice versa, since Reading Comprehension more generally calls upon the ability to discern connections and various forms of reasoning, whereas the cognitive processes in Dutch Spelling, such as discerning and using analogies and applying orthographic rules, are much more specific.

Based on the considerations above the following model is postulated as a starting-point for the analyses.

Insert figure 1 here

The latent variable Decoding Skills influences both Reading Comprehension and Spelling Skills. The latent variable Reading Comprehension only influences Spelling Skills. It is to be expected that the strength of the causal relations between the latent variables will change during the development of reading in primary school. The model is very simple, but a model is not wrong just because it is simple. It is wrong if it makes false predictions, or badly fits the data. But even more important, if it is wrong, one can see where it went wrong and so increase our understanding, a benefit that complex models seldom afford. Thus we are determined to take what we see as the simplest possible view until the data force us to do otherwise.

The third question is whether causal effects found in a cross-sectional approach will be "explained away" in a longitudinal approach. Causal effects found in cross-sectional designs often decrease or disappear altogether in favour of "memory effects" in longitudinal research. It is very important to know to what extent this is the case, both for the diagnosis of reading and spelling difficulties, and for the development of reading and spelling curricula.

Subjects, Data and Instruments

The group investigated consisted of two samples, each consisting of pupils from the first grade of 12 randomly selected schools. The first group used the beginning reading program "Veilig Leren Lezen" (Learning to Read Safely) (Caesar, 1980), the second group used the program "Letterstad" (Lettertown) (Kooreman, 1976). The project started in August 1979 with a cohort of 582 children. After six years 398 of them were still in the sample (= 68,4%). Because the results of the two groups largely coincided, we are reporting only the results of the first one here.

The data have been collected in grades 1, 2, 3 and 6. Most instruments are nationally standardized tests (see Table 1).

Insert table 1 here

Analyses by means of the LISREL-program

In figure 1 an attempt was made to construct a causal model partly based on what is known from the literature about the relation between decoding skills, reading comprehension and spelling skills.

Causal models are an attractive means for the formulation of well-specified questions in an empirically testable form. Rogosa (1979) has stressed the importance of underlying models in problem formulation and data analysis in longitudinal research. The construction of causal models is a two-stage procedure involving the structural model, which specifies the relations between the important constructs, and the measurement model, which relates unobserved constructs to their observable manifestations.

When it comes to the formulation of a causal model, one of the most difficult problems, arises because many of the concepts and the constructs that we want to work with are not directly measurable. Although such hypothetical concepts and constructs -or latent variables, as we shall call

them- cannot be directly measured, a number of variables can be used to measure various aspects of these latent variables more or less accurately. Thus, although the latent variables cannot be observed directly, they have operational implications for relationships among observed variables. Each indicator has a relationship with the latent variable, but if we take one indicator alone to measure the latent variable, we obtain a biased measurement. By using several indicators of each latent variable we get a better measurement.

Another reason for using latent variables in a model is that most of the measurements employed contain sizable errors of measurement (observational errors) that, if not taken into account, can cause a severe bias. Errors of measurement occur as a result of imperfection in the various measurement instruments (tests etc.), which are used to measure such abstractions as decoding skills, reading comprehension and spelling skills. Even if we could construct valid measurements of these concepts, it is usually impossible to obtain perfectly reliable measurements. Special care must be taken to obtain measurements that really measure the latent traits or hypothetical constructs that we are interested in.

Often it is impossible, or even undesirable, to specify the model completely, since there may be other models that are equally plausible. In such a situation it is necessary to use a technique of analysis that will tell us which of a number of alternative models is the most reasonable. Also, if there is sufficient evidence to reject a given model, because of a poor fit with the data, the technique should be such as to suggest which part of the model has caused the poor fit.

One important part in the application of LISREL is the assessment of the fit and the detection of lack of fit of the model. The goodness of fit of the whole model may be judged by means of the overall Chi-square-value and its associated degrees of freedom. It should be emphasized that for various reasons, the use of Chi-square is not valid for testing a model in most cases (Jöreskog & Sörbom, 1985). However, instead of regarding Chi-square as a test statistic one can regard it as a goodness of fit measure in the sense that large Chi-square-values correspond with a bad fit and small Chi-square-values with a good fit. The degrees of freedom serve as a standard for determining whether Chi-square is large or small. Large sample sizes and deviations from normality tend to increase Chi-square over and above what can be expected due to specification error in the model.

Another measure of overall fit is the Goodness-of-Fit Index (GFI). Unlike Chi-square, GFI is independent of the sample size and relatively

robust against departures from normality. Unfortunately, however, its statistical distribution is unknown, even under idealized assumptions, so there is no standard to compare it with (Jöreskog & Sörbom, 1985).

It should be emphasized that the measures Chi-square and GFI are measures of the overall fit of the model to the data, and do not express the quality of the model judged by any other internal or external criteria. For example, it may happen that the overall fit of the model is very good, but that the squared multiple correlations indicate that one or more relationships in the model are very poorly determined or vice versa. Furthermore, if any of the overall measures indicates that the model does not fit the data well, it does not reveal what is wrong with the model.

When a model has been found not to fit the data adequately in terms of the criteria described above, the question arises how the model should be modified to fit the data better. What the model should be like cannot be decided well-founded on a purely statistical basis, however. The best situation is if there is a theory that can be used to decide how the model should be changed. However, in many cases the theory does not provide such information. In such cases it is useful to have some information from the data analysis that can support the decision on how to modify the model. In a LISREL-analysis this is provided by the modification indices. For each parameter which is fixed in the model there is a modification index equal to the expected decrease in Chi-square if this single parameter alone would be free. A practical procedure to modify a model is the following. Find the largest modification index for all fixed parameters. If it is larger than five, set the corresponding parameter free and re-estimate the model. The decrease in Chi-square for the new model as compared with the old one should be at least equal to the modification index. When the fit of the model is still bad, this procedure can be repeated.

The reason for the choice of the LISREL-method is the opportunity this approach offers (a) to evaluate by means of the maximum likelihood method both the global as well as the local fit of models in which (b) both cross-sectional and longitudinal effects may be included, and (c) the possibility to employ observed as well as latent variables.

All the analyses in this study were carried out by means of the LISREL-program, version VI: Analysis of Linear Structural Relationships by Maximum Likelihood and Least Squares Methods (Jöreskog, 1985). The variance-covariance matrices of the measured variables were used as the input for the program.

Results

This study examines the relations between the factors Decoding Skills, Reading Comprehension, and Spelling at various stages in primary education. Correlation coefficients indicate the extent to which two or more variables tend to vary together.

The output of the LISREL-program provides a...ong other things correlation coefficients between the factors involved.

Insert figure 2 here

In figure 2 these correlation coefficients are shown. In this model both the measured variables (squares) and the factors or latent variables (circles) have been marked. The numbers in the squares refer to the tests in table 1. The factors have been labelled as follows: R is Reading, DS is Decoding Speed, RC is Reading Comprehension and SP is Spelling. In most cases the correlations between the factors with the same name are very high. This is also true for grades 3 and 6, even though the time interval between the points of measurement is three years. The correlations between factors with different names vary and are generally lower, but they are quite considerable. In a correlational sense these factors are not independent.

In figure 1 a model or explanatory scheme was presented. It is this explanatory model that determines the type of analysis to be applied to our data. Having completed an analysis, we are in a position to determine whether the data are consistent with the explanatory scheme. If the data are inconsistent with the explanatory model, doubt is cast on the theory that generated it. Consistency of the data with an explanatory model, however, is not proof of a theory; it only lends support to it. It is possible for the same data to be consistent with a competing causal model. What is needed, then, is a method of analysis designed to shed light on the tenability of the model. One such method is path analysis. The path diagram is a useful device for displaying graphically the pattern of causal relations among variables. The output of the LISREL-program provides path coefficients to display the path diagram. For the sake of clarity the measured variables (squares) have been deleted in figures 3 and 4. Only the path coefficients belonging to the structural equations have been indicated. A path coefficient, which is in fact a standardized partial regression coefficient (beta weight), indicates the direct effect of a variable taken as a cause on a variable taken as effect.

Insert figure 3 here

As mentioned above one should not regard Chi-square as a test statistic. It is a goodness (or badness) of fit measure in the sense that large Chi-square-values correspond with a bad fit and small Chi-square-values with a good fit. The degrees of freedom serve as a standard for determining whether Chi-square is large or small. The "Goodness of Fit Index" is a measure of the relative amount of variances jointly accounted for by the model. Unlike Chi-square the "Goodness of Fit Index" is independent of the sample size and relatively robust against departures from normality.

Insert table 2 here

As shown in table 2 the Goodness-of-Fit-Index is high in all cases. In grade 3 Chi-square is relatively large. Considering the corresponding Goodness-of-Fit-Index, this may be due to deviations from normality of some test scores. The path coefficients in figure 3 confirm the expected influence of Decoding Skills on Spelling. This causal relation is partly direct and partly indirect via Reading Comprehension. It is remarkable that in grade 3 the influence of Reading Comprehension on Spelling is lower compared to the first two grades. On the other hand, in grade 6 this influence increases considerably. The direct influence of Decoding Skills on Spelling is smaller than in the first 3 grades. The interpretation of these changes may be that in the sixth grade spelling tests are more complicated and require application of spelling rules. Word-specific knowledge of invariable words is not sufficient to spell correctly. In Dutch orthography this applies in particular to conjugated verbs.

Insert figure 4 here

In this research an important question is whether causal effects found in a cross-sectional approach decrease or even disappear altogether in favour of "memory effects" in a longitudinal analysis. Figure 4 presents the results from longitudinal analyses with the same subjects and by means of the same LISREL-program. In most cases it is very difficult to obtain a satisfactory fit with a comprehensive model. Starting with parts of the model it turned out to be possible to compose the final model with an acceptable fit. Attempts to improve the model shown in figure 4 were not succesful. Chi-square of this model with 504 degrees of freedom is 709.27

and the Goodness of Fit Index is .815. This is quite an acceptable fit for such a comprehensive model.

In this model data have been added from an earlier point of measurement, namely four months after the start of formal reading instruction. At this stage it appeared not possible to distinguish empirically between Reading and Spelling. In addition, the modification indices indicate that Reading, that is the skill to sound out words, is a cause with regard to Decoding Skills rather than an effect at this stage of development. Noteworthy is the unexpected influence of Reading (grade 1A) on Reading Comprehension in grade 2. Apparently differences in Reading Comprehension in grade 2 are not entirely attributable to Decoding Speed and Reading Comprehension at the end of grade 1. An explanation for this direct influence may be a feedback mechanism. Individuals who have advantageous early reading experiences are able to utilize new reading experiences more efficiently. Many things that facilitate growth in Reading Comprehension ability are developed by reading itself. The increased reading experiences of children who break the spelling-to-sound code early will thus have important positive feedback effects. Stanovich (1986) mentions phonological recoding ability as one of the important factors for explaining the richer-get-richer and the poor-get-poorer patterns of reading achievement.

When we compare the path diagrams in figure 3 with the results in figure 4, it is clear that they differ considerably. The arrows from DS3 to RC3, from RC3 to SP3, from DS6 to RC6 and DS6 to SP6 have disappeared, because the corresponding path coefficients are not significant. Although the path coefficient for the influence of RC1 on SP1 is not significant at the 5 percent level (t= 1.20), this arrow has been kept in, because with the "Lettertown group" this causal relation is clearly significant. In addition, the path coefficients of the remaining arrows decreased considerably. These results confirm the assumption that with a longitudinal approach cross-sectionally found causal effects decrease and sometimes disappear in favour of "memory effects". This finding is important for a theory of reading development. Some researchers have emphasized that the causal connections between variation in reading achievement and the efficiency of various cognitive processes may change with development (Stanovich, 1986; Chall, 1983). In a lot of research on individual differences in the cognitive skills of reading this is not reflected adequately. Individual differences may be a causal determinant of variation in reading achievement early in development, but at some point they have no further effects on the level of reading efficiency. The results of this longitudinal study show that in

grade 6 correlations and path coefficients between Decoding Skills on the one hand and Reading Comprehension and Spelling on the other remain as a remnant of a causal connection that existed during an earlier developmental stage, but that these relationships are developmentally limited.

In most cases the connections between the latent variables of the same name are much stronger than the relations with the other ones. This is an indication that the differences related to these latent variables are rather stable. This applies especially to Decoding Skills.

An interesting question is, whether the rather strong influence of Reading Comprehension on Spelling in grade 6 is attributable to specific characteristics of Dutch orthography or that this relationship exists also with other spelling systems.

Conclusions and discussion

In recent years there have been a number of attempts to design models of the reading processes and of learning to read (Singer & Ruddel, 1976). To a certain extent some models have been empirically validated (Curtis, 1980; Butler et al., 1985; Juel et al. 1986). In only a few instances, however, the LISREL procedure was used, for example in the research by Frederiksen (1982). The abovementioned authors try to break up the reading process into components or subskills in order to gain more insight into the course of the complex reading process and its development. According to them, it is essential to specify the component or subskills very accurately and, if possible, to make them operational in very specific tasks. Most tests in the present study are too complex to enable one to distinguish such components. This difficulty can be partly solved by defining components as factors on which the tests load. Although the LISREL-models presented here may not be considered ideal, they derive their value from the interplay between theory and empirical data. The model in figure 4 cannot be considered definite. Further testing among other populations and under different circumstances is called for in order to justify generalizations.

Drawing conclusions for reading instruction from research data requires caution. Yet some guidelines may be suggested. As shown in figure 4 the proportions of explained variance in grades 2, 3 and 6 are considerable. If the same tests are used with a comparable group of students, it is possible to predict reading and spelling achievements in a rather reliable way. An experimental computer program, based on a longitudinal LISREL-model, has been designed, which can be used by teachers for developmental

diagnosis of reading and spelling difficulties (Oud et al., 1986). Especially students with poor achievements have to be examined on discrepancies that may exist between the development of Decoding Skills, Reading Comprehension and Spelling.

The results of this research are also of importance for the planning of course materials, and the formulation of objectives and goals for various stages of reading development. In an integrated course of formal reading instruction, a fair amount of attention will have to be paid to the specific nature of Decoding Skills, Reading Comprehension and Spelling (see also Shanahan, 1984). Although the variables were measured fairly globally, the clear relations that have nevertheless been found with two independent groups are remarkable, and they make it clear that longitudinal research is indispensable.

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Table 1: Instruments administered at various points of measurement. The letters refer to factors on which the measured variables load.

Point of time 1A, grade 1:	
After 4 months of formal reading instruction	Factor
1. One Minute Test (Caesar)	DS
2. Beginning Reading Test	R
3. Reading Comprehension	R
Point of time 1B, grade 1:	
After 8 months of formal reading instruction	Factor
4. One Minute Test (Caesar)	DS
5. AVI reading speed (text)	DS + RC
6. Reading Comprehension (CITO, 1A)	RC
7. Spelling, words (CITO, 2)	SP
8. Spelling, sentences (B1)	SP
Point of time 2, grade 2:	Factor
9. One Minute Test (Brus)	DS
10. AVI reading speed (text)	DS + RC
11. Reading Comprehension (CITO, 2)	RC
12. Written assignments 2	RC
13. Spelling, words (OBCE, 2)	SP
14. Spelling, sentences (C)	SP
15. Spelling, sentences (D)	SP
Point of time 3, grade 3:	Factor
16. One Minute Test (Brus)	DS
17. AVI reading speed (text)	DS + RC
18. Written assignments 4	RC
19. Reading Comprehension (CITO, 3)	RC
20. Spelling, words (OBCE, 3)	SP
21. Spelling, sentences (E)	SP
22. Spelling, sentences (F)	SP
Point of time 6, grade 6:	Factor
23. One Minute Test A (Brus)	DS
24. One Minute Test B (Brus)	DS
25. Reading Test: Main Idea	RC
26. Vocabulary Test	RC
27. Silent Reading (I.S.I.)	RC
28. Cloze Test	RC
29. Reading 1 (CITO)	RC
30. Reading 2 (CITO)	RC

31. Spelling 1 (I.S.I.)	SP
32. Spelling 2 (I.S.I.)	SP
33. Spelling 1, verbs (CITO)	SP
34. Spelling 2 (CITO)	SP

Table 2: Measures for the fit of the model, resulting from seperate analyses for each grade, and corresponding to the path diagrams in figure 3. (N= 178)

Grade	Chi-square	df	p	Goodness of Fit Index
1	2.86	2	.238	.994
2	10.13	11	.518	.983
3	26.85	11	.005	.963
6	89.70	52	.001	.921

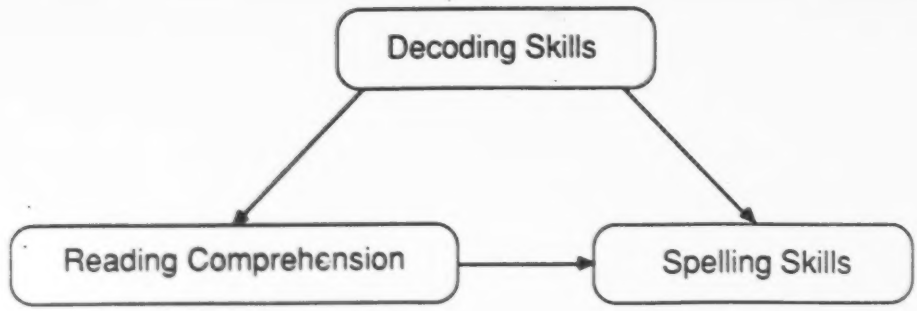

Figure 1 The model postulated as a starting-point for the analyses

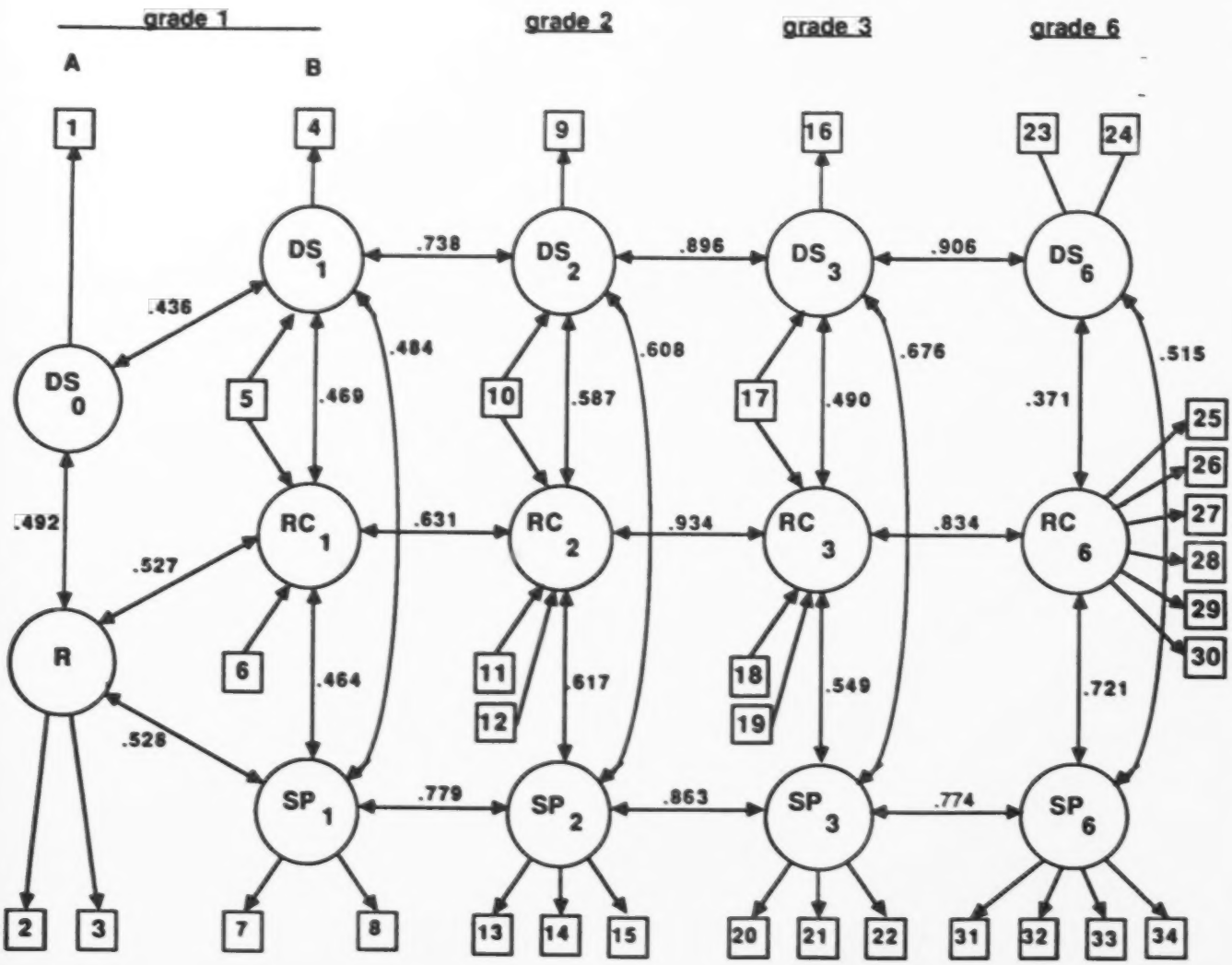

Figure 2 Correlation coefficients between the latent variables Reading (R), Decoding Speed (DS), Reading Comprehension (RC) and Spelling (SP). The squares indicate the measured variables

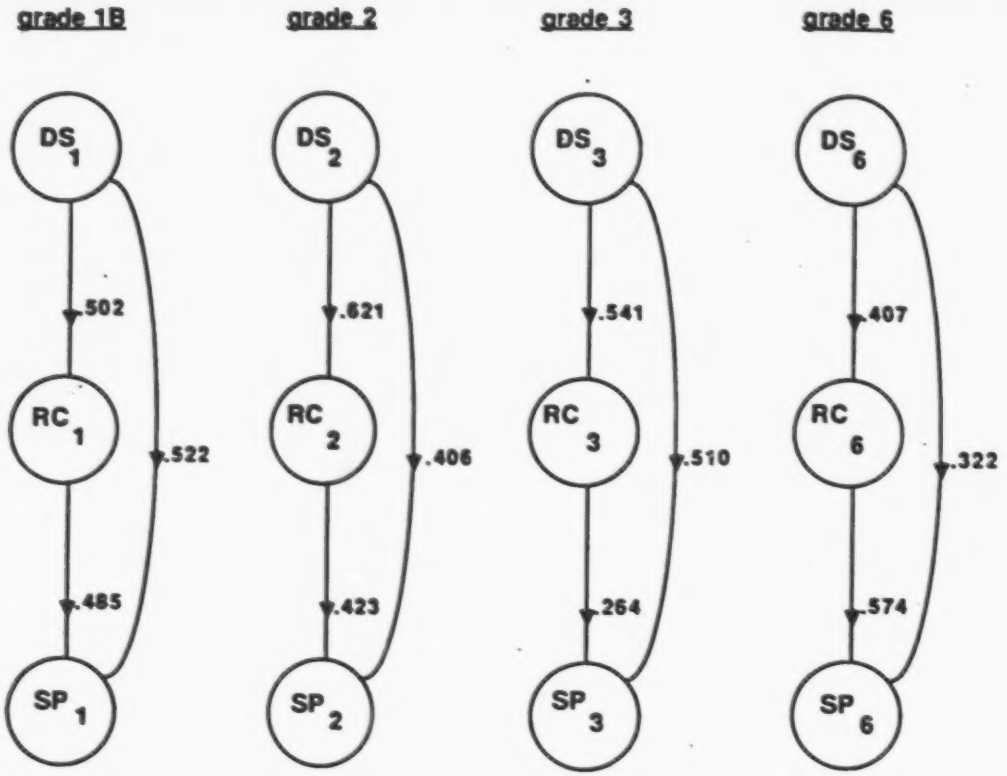

Figure 3 Path coefficients resulting from cross-sectional analyses

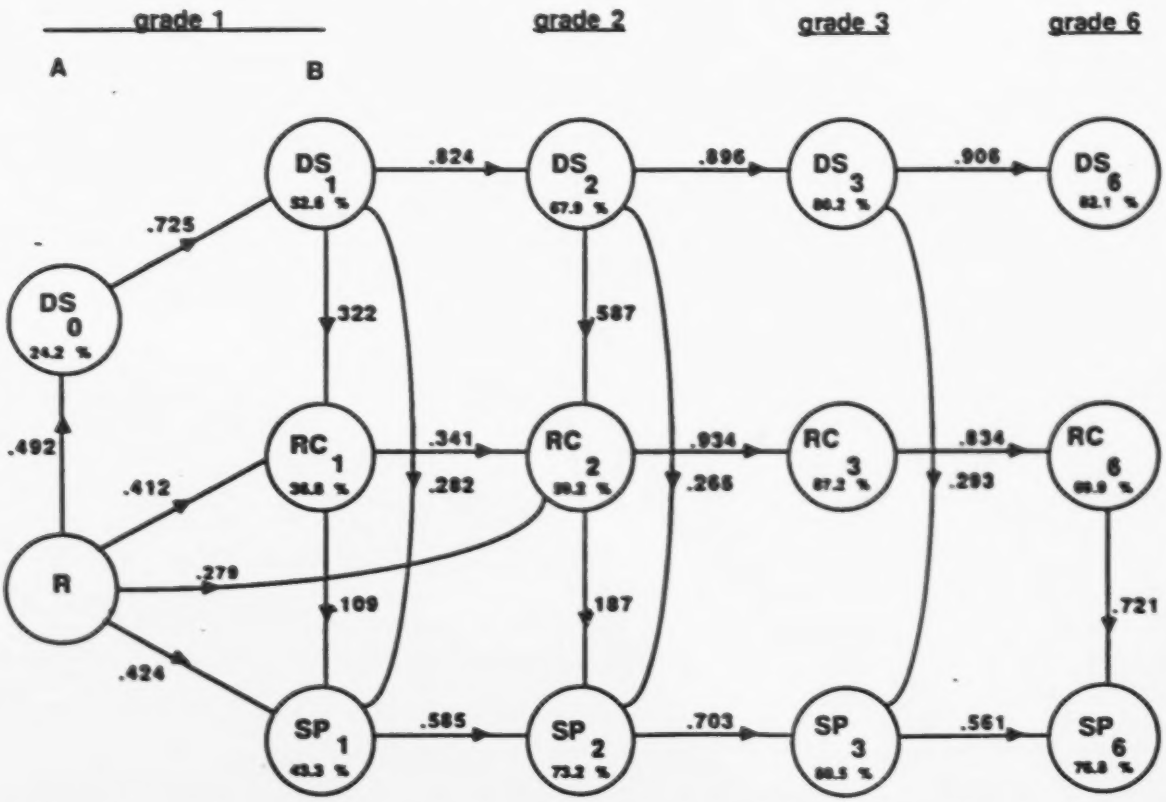

Figure 4 Path coefficients resulting from a longitudinal analysis by means of the LISREL-program. The percentages in the circles indicate the proportion of explained variance